The DoD Architecture Framework Views as Requirements Vehicles in a Model Driven Architecture Systems Development Process

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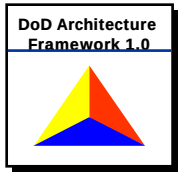
Agenda

- Architecture Framework Overview
- A Systems Engineering Perspective of Architecture Views
- An Integrated Architecture Approach
- Application to JSSEO Model Driven Architecture Development
- Tool Adaptation
- Requirements Management
- Summary

Purpose

- Describe our Approach to Extending DoDAF to Unify Architecture, Requirements and Requirements Traceability
- Demonstrate that the DoDAF can be Inline with the Systems Engineering Process

DoDAF Background



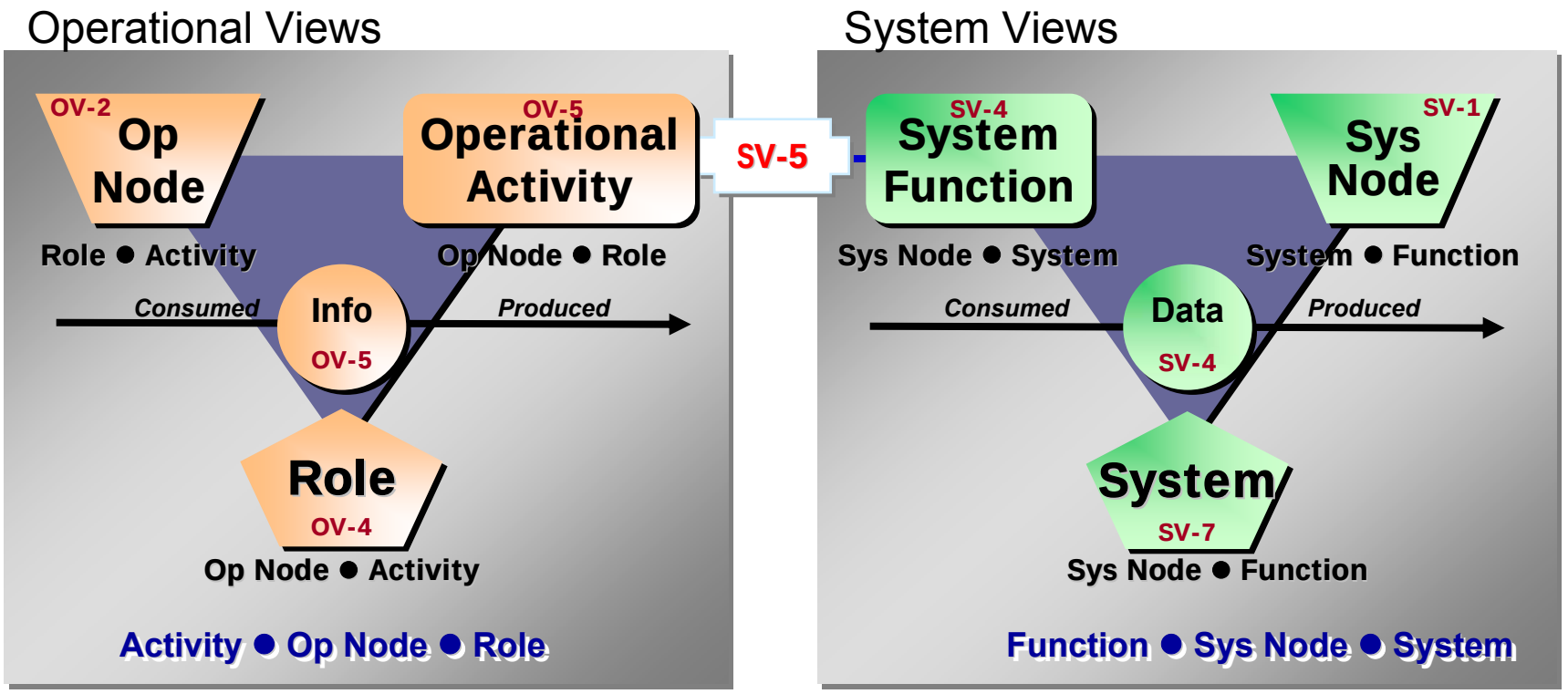
DoD Architecture Framework v1.0

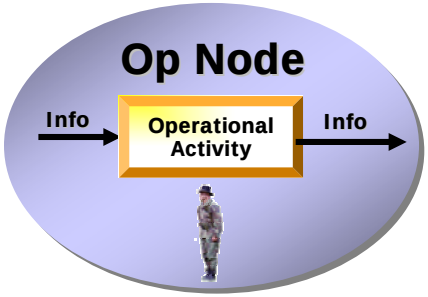
- DoDAF is Mandated for Representing Architectures for the DoD
  - Operational, System, Technical Views (AV, OV, SV, TV)
  - Addresses Structure, Data, Behavior
  - Mainly Diagrams or Tables
- DoDAF is Governed by a Working Group with Representatives from Across DoD Services and Agencies
- *Focus Should Be on the Underlying Meta-Data*
  - What The Diagrams Mean, Not What They Look Like
- Not Intended as a Systems Engineering Tool, or as a Primary Requirements Vehicle
  - Tendency to be Descriptive rather than Prescriptive
  - Doesn't Mandate that Requirements be Specified
  - Assumes (but doesn't require) a Disciplined Process with Strict Consistency Between Products

Challenges for Our Project

- Desire to use DoDAF to Support Systems Engineering
  - Architectures as more than just a Descriptive Report
- Coupled Architectures – Operational, System, Software
- Linked, Traceable Requirements at all Levels
- Address Model Driven Architecture (MDA) Challenges
  - Integrated Architecture Behavior Model (IABM) to meet needs of Single Integrated Air Picture (SIAP)
  - Distributed Nature of the Desired System
  - Rapid Development Prior to Definition of the Full Set of Requirements -- Evolutionary/Iterative Development
  - Iterative Development, Constant Refinement of Requirements
  - OO Based Design Processes Based on UML notation

Relating DoDAF OV and SV Products





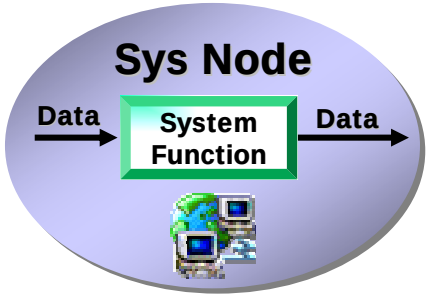
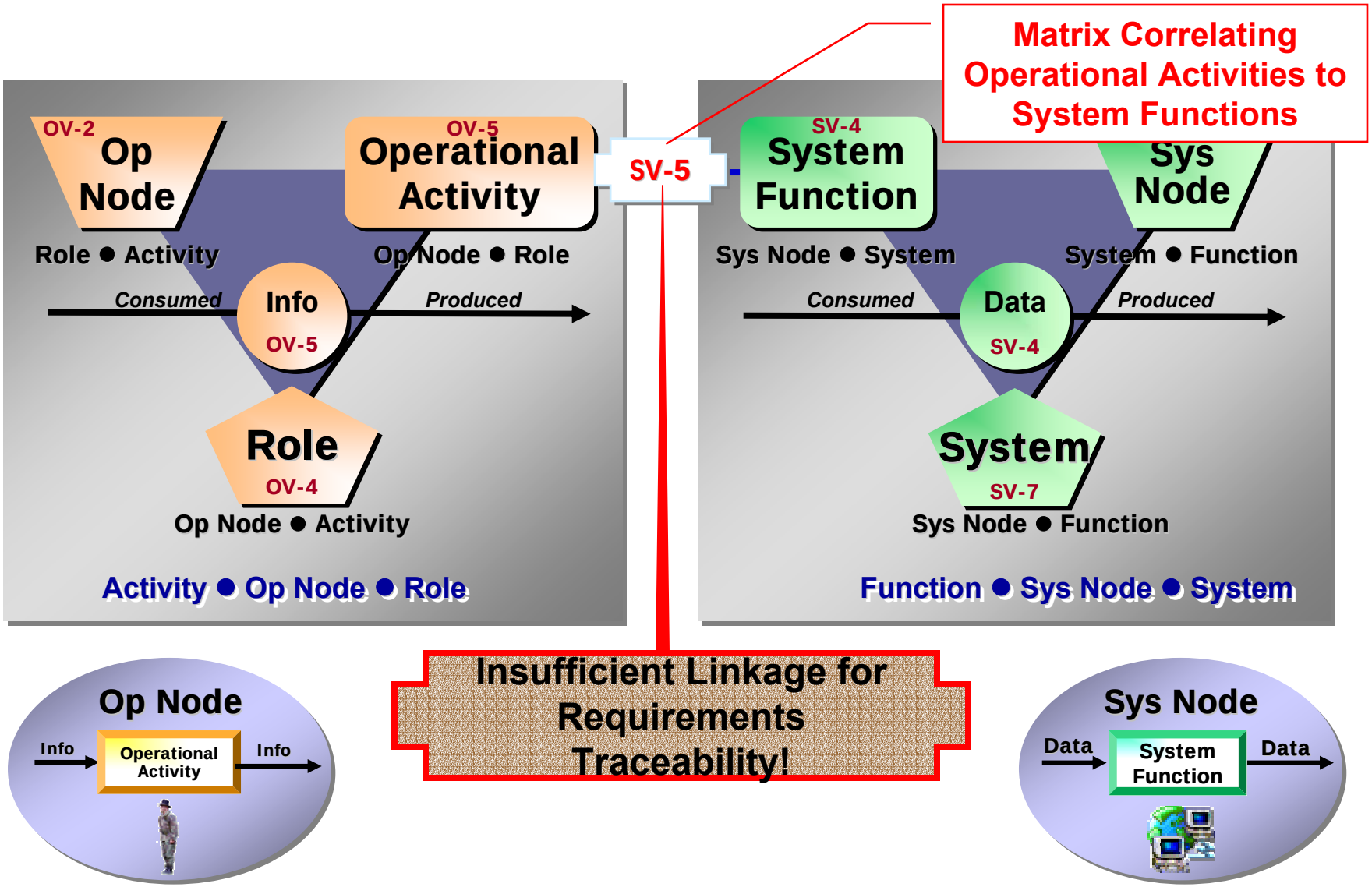


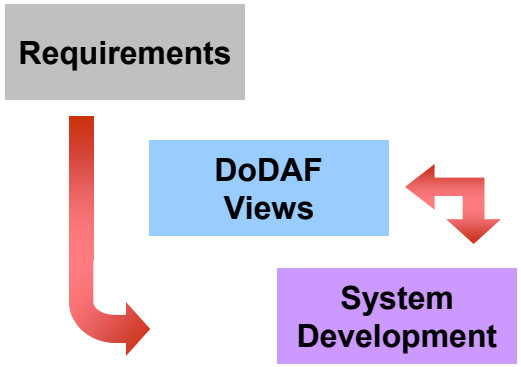
Diagram Concept from Steve Ring, MITRE Corp.

DoDAF OV to SV Connection - *Deficiencies*

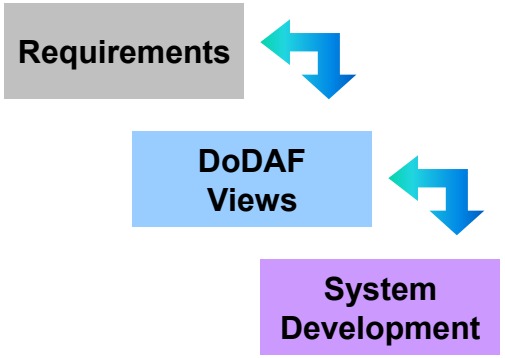


A Systems Engineering View

- Requirements Allocation and Traceability Provide Rigor Needed to have Architecture Views Support System Engineering
- Need to Establish
  - Linkage Between Requirements and Architecture Elements at Each Level
  - Linkage Between Requirements at Different Levels
- Conventional Approach to DoDAF vs Requirements Aligned Approach



Conventional Relationships



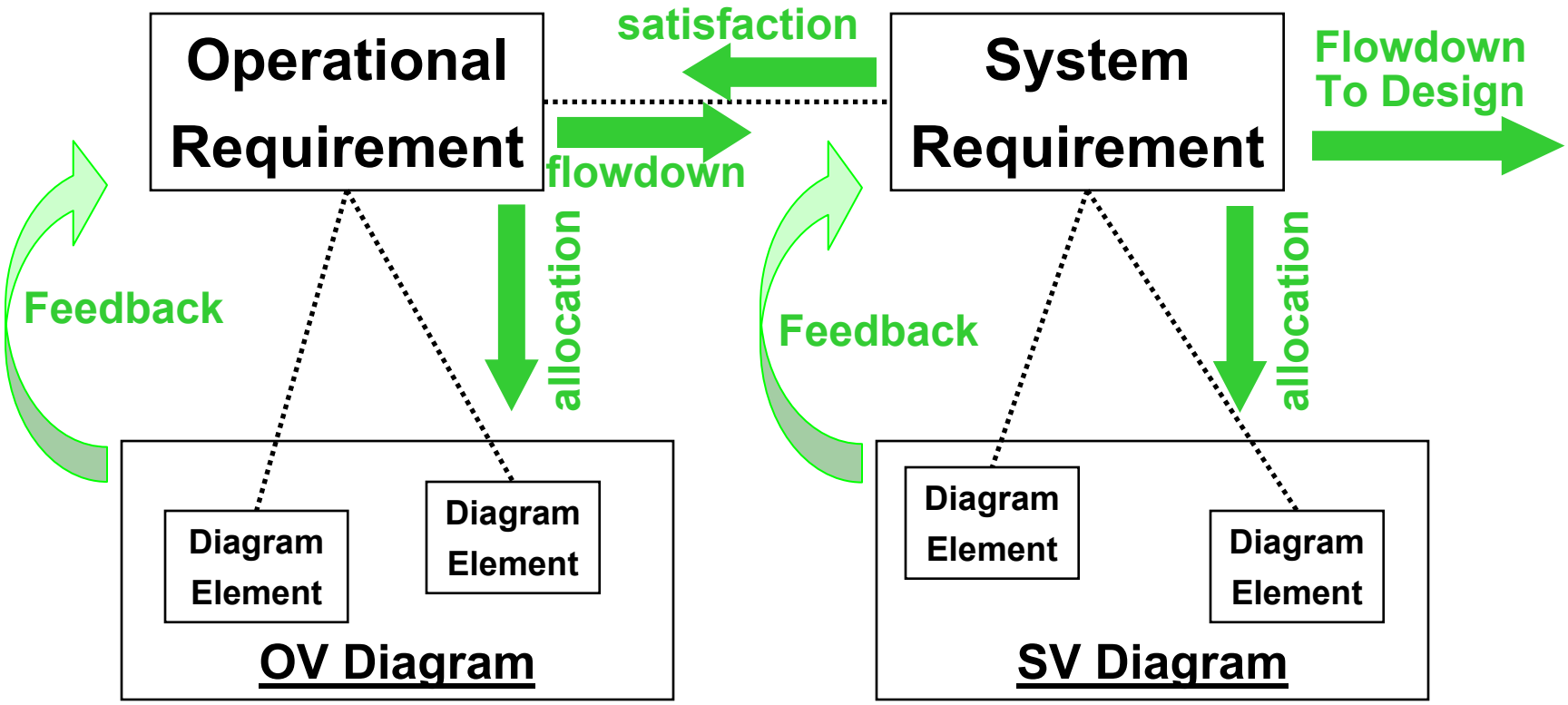
Aligned Requirements Relationships

An Integrated Architecture Approach

- Architectures Capture Requirements in Context
  - Architecture Views are Relevant to the Systems Engineering Process and Become De Facto Living Documents with the Evolutionary System Design
  - Separated Requirements may not have the Meaning they have in Context, or in a Specified Sequence (Using *Rules*, *Statecharts* or *Sequence* Representations)
- All Requirements get Implemented through Something in the Architecture, and there Should be Nothing in the Architecture that isn't there to help Satisfy Requirements
- All Elements in an Architecture Should be Satisfying one or more Requirements
  - Richer and Rigorous Correlation Between Requirements at Different Levels of the Architecture
  - Can be Design-Derived Requirements
- Each Requirement Should be Allocated to at Least One Architecture Element Somewhere
  - If all Requirements Should be Testable, then there must be Something to Test

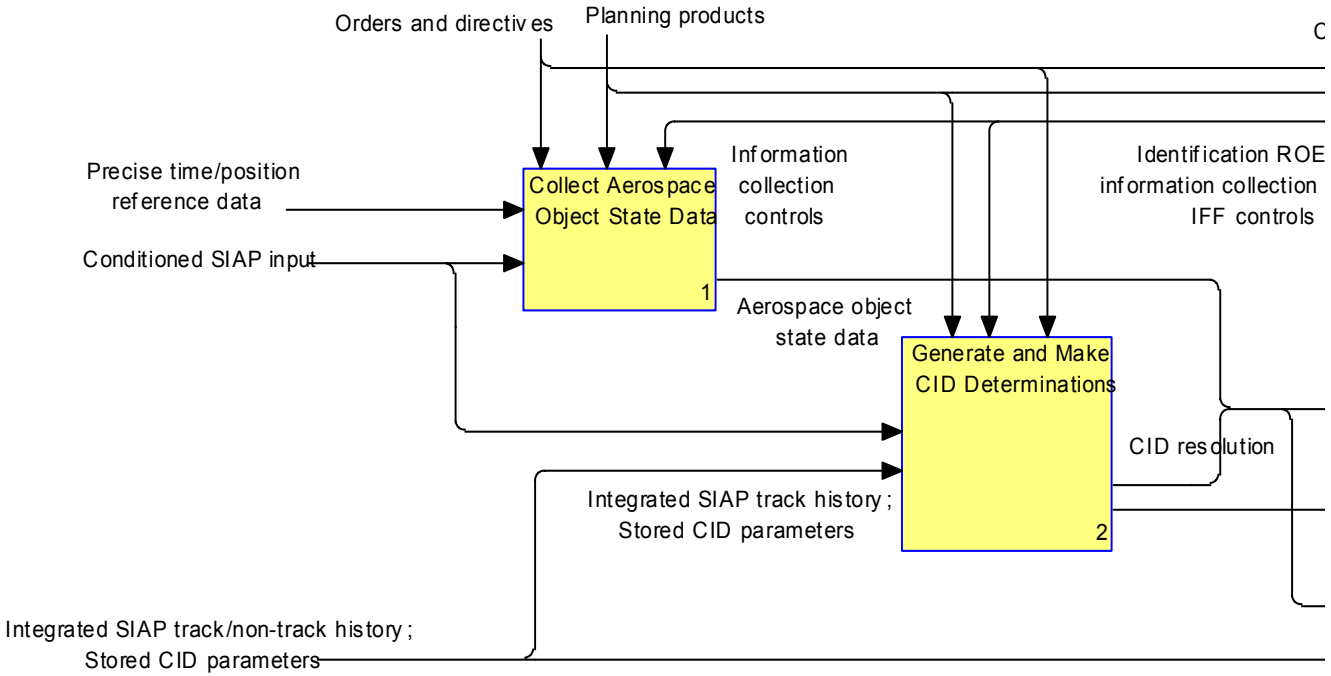
Architecture – Requirements Traceability

- Requirements Apply to More than Just Functions
- Data, Interfaces, and Behavior Should also have Requirements, and be Related between OVs and SVs



Assigning Requirements to an Operational Activity (Example)

- Portion of one of the OV-5 Dataflow Diagrams
- Requirements can be Attached to
  - Operational Activities (boxes)
  - Information Exchanges {data} (lines)



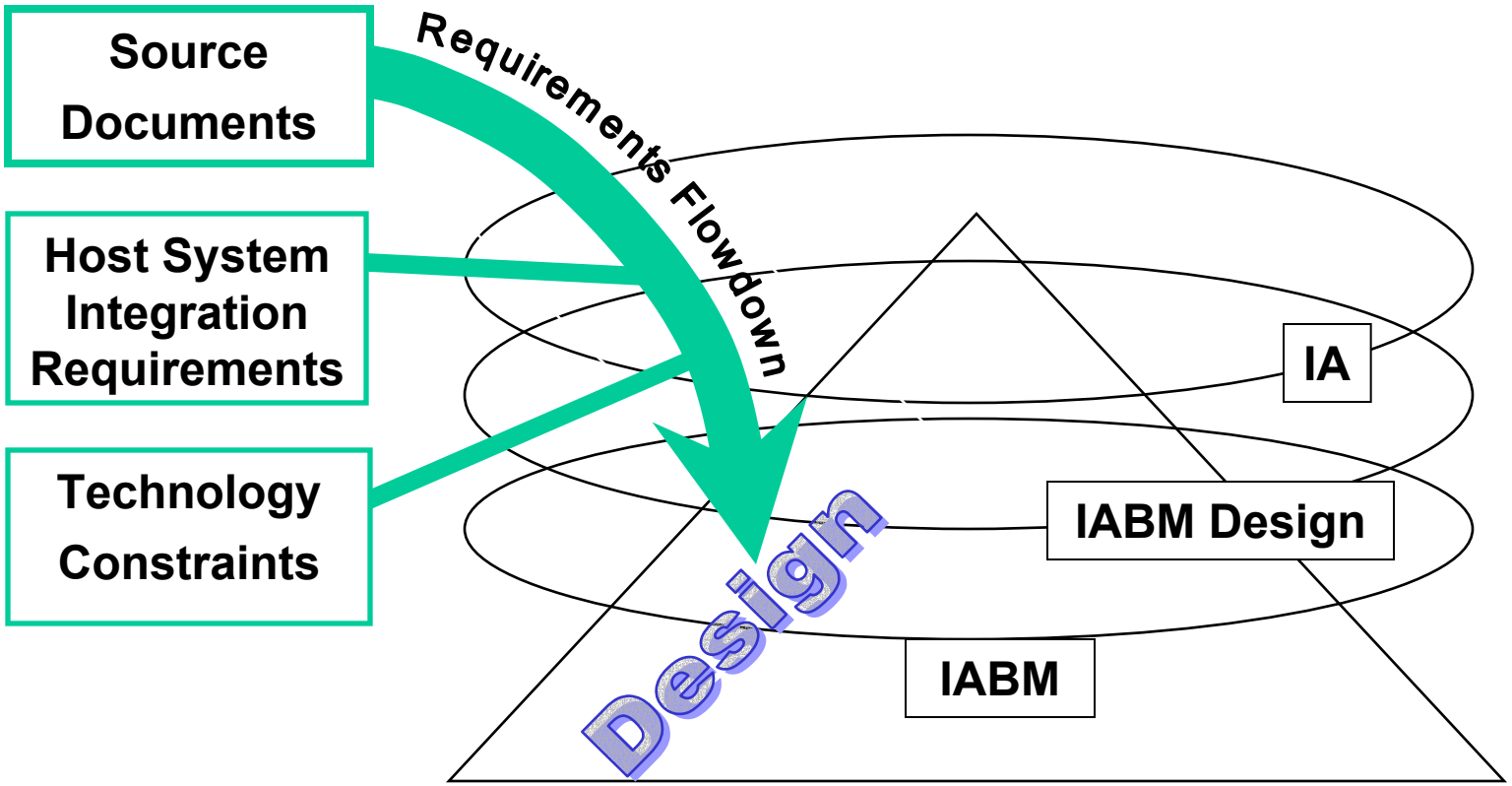
Comprehensive Approach for JSSEO

- JSSEO Project Characteristics
  - Based on Model Driven Architecture (OMG)
  - One Fact, One Place
  - Requirements Traceability
  - Auto-Generation of Documentation
- Agile Development
  - Iterative Requirements Definition and Refinement
  - Appropriate for "Disruptive Systems" *
  - Distributed System and System Requirements
- Support Implementation of Software to Heterogeneous Host Systems
- Tailoring of DoDAF products
  - UML as Basis for System Views

* Clayton M. Christensen, *The Innovator's Dilemma*

Role of an Integrated Architecture within JSSEO

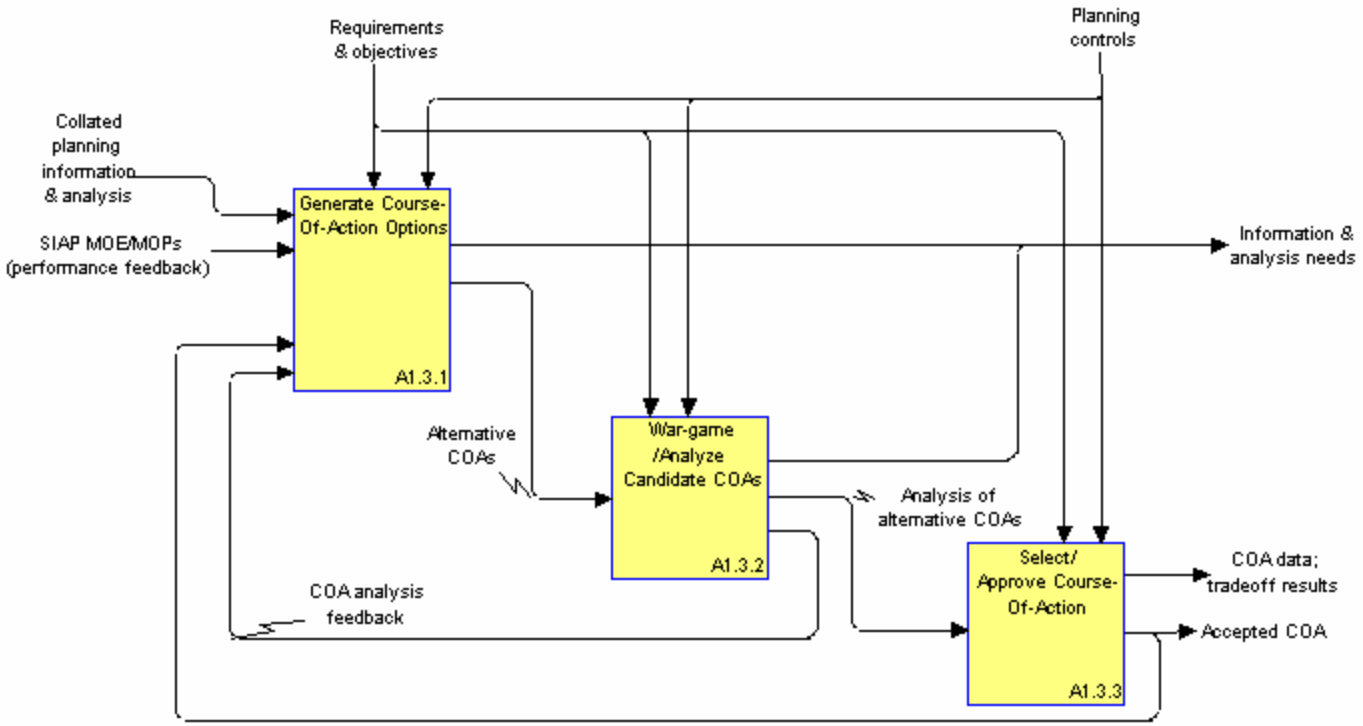
- Integrated Architecture (IA) Contains
  - Operational and System Architecture
  - Operational and System Requirements



Extending DoDAF to Address JSSEO MDA

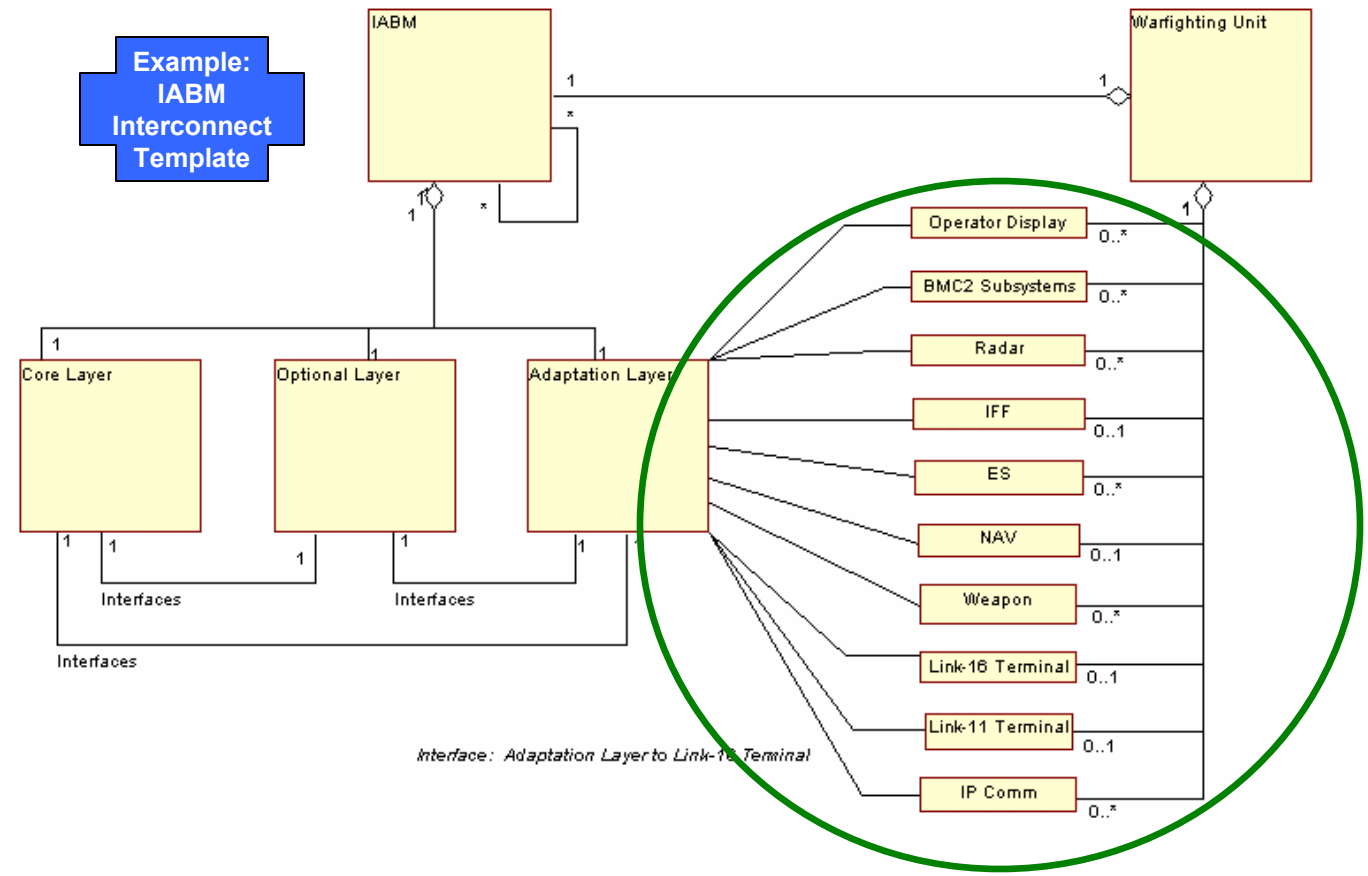
- Diagram Adaptation Primarily on the SV side.
- SV-1, -2, -4, -6, -11: Use UML Class and Object Diagrams
  - Variety of Uses
- Interconnect Template
  - The IABM, its Layers, and its Interfaces to the Host System
  - Classes Defined for Commonality
  - Object Instance Versions for each Host System
- Capability Areas
  - “Virtual” Classes Defined to hold Domain-Level Requirements
- Interface Specification
  - Associations/Links can have Requirements Attached, and Support Message Definition

IA Operational Views & Requirements



- Operational Requirements (Derived from Primary Sources) Associated with Diagram Elements

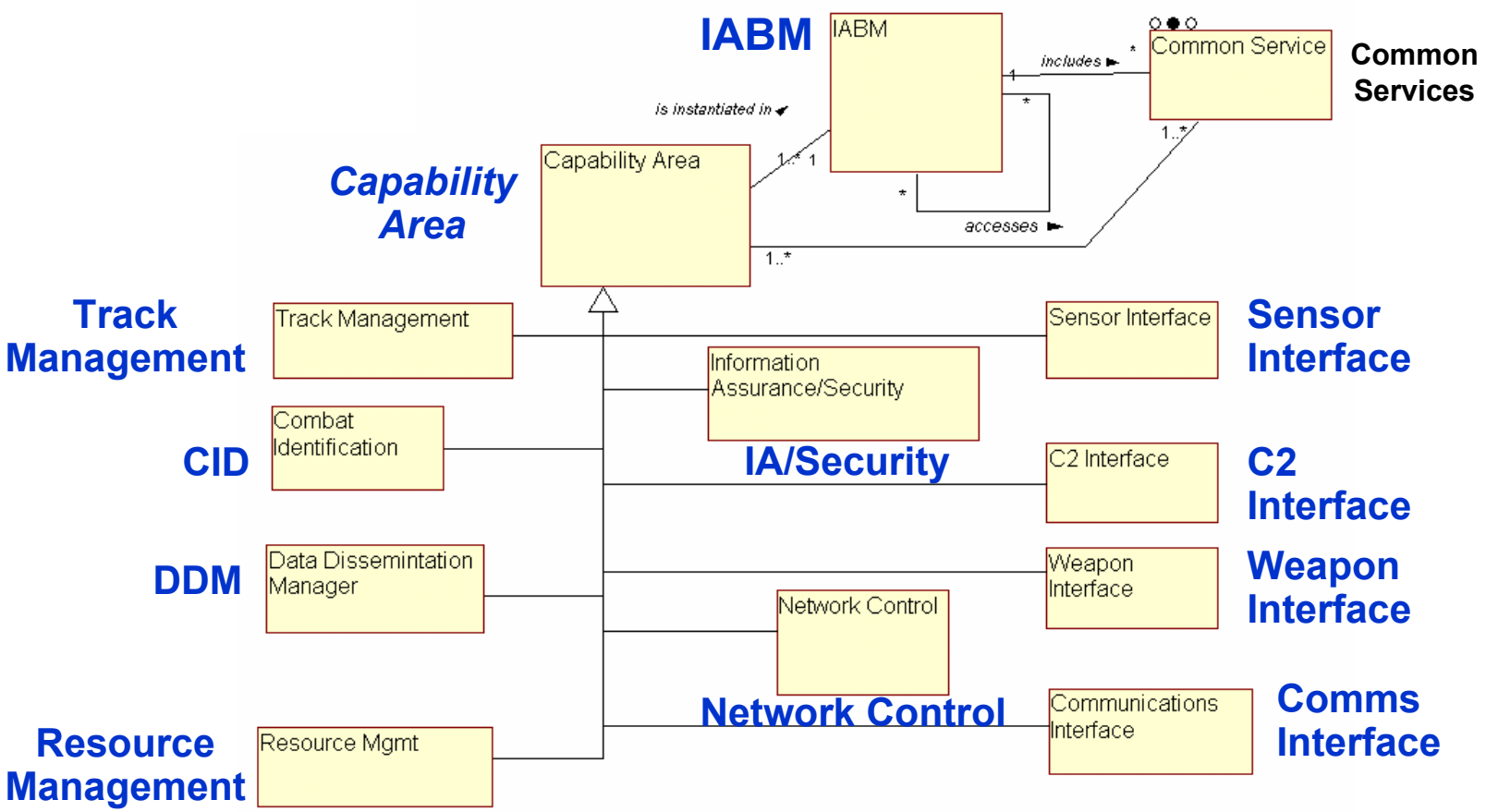
IA System Views & Requirements



- System Requirements Allocated to System View Elements
- Some Requirements derived from Architecture Context (Interfaces)

IABM Capabilities Object Model (Example)

- Links System Views with IABM Design
- IABM "Capabilities" are Virtual Objects used to hold Sets of Related Domain* Requirements.



* Kennedy-Carter iUML Development Tool Terminology for a Collection of Classes

Value of Architecture/Requirements Process to JSSEO

- Unified Repository of Integrated Information
  - Allows Automated Detection of Mismatches
  - Support for Automated Document Generation
  - Integrated Product Focus for Configuration Control & Management
- Efficiency: Engineers Think, Tools Help Keep Track
- Fewer Tools Means Fewer Manual Translations between Tools
  - Every (manual) Translation Provides an Opportunity for Mis-translation
  - Translations Mean More Effort, More Complicated Updating Process, Lower Probability of Continued Success
- Up-To-Date Design
  - Architecture, Requirements, Design Updated Monthly

Implementing the Solution

- Architecture Tool Adaptation
  - Architecture Diagramming and Requirements Management Tools Configured to Support the JSSEO Development Process
  - Automated Data Exchange Between Tools to Minimize Data Entry Duplication
- Requirements Management
  - Flexible Scheme for Identifying and Tracing Requirements
  - Requirements Managed Individually, not as a Set within a Specification
- Metrics, Reports and Status Monitoring
  - Oriented Toward Determining Completeness of Requirements Traceability
  - Account for All Aspects of Traceability
    - Requirement to Source
    - Requirement to Requirement
    - Requirement to Architecture View Diagram Elements
    - Requirement to Development Tool Domains

Adapting Tools

- No Single Tool Meets All Needs - Requires Suite of Interoperable Tools

PRIMARY TOOLS

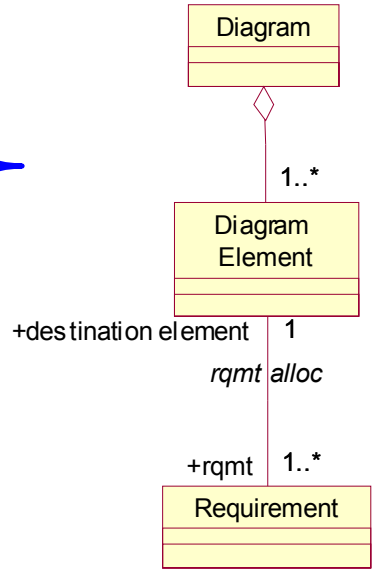
- Popkin Systems Architect
  - DoDAF Views (Diagrams)
  - Requirements (multiple levels)
  - Associates Requirements with Architecture Elements (Symbols & Definitions)
  - Encyclopedia of Architecture Data Stored in MS SQLServer
- Telelogic DOORS
  - Requirements Repository
  - Traceability Management
  - Interface to Pass Requirements into Kennedy-Carter iUML Development Tool

SUPPORTING TOOLS

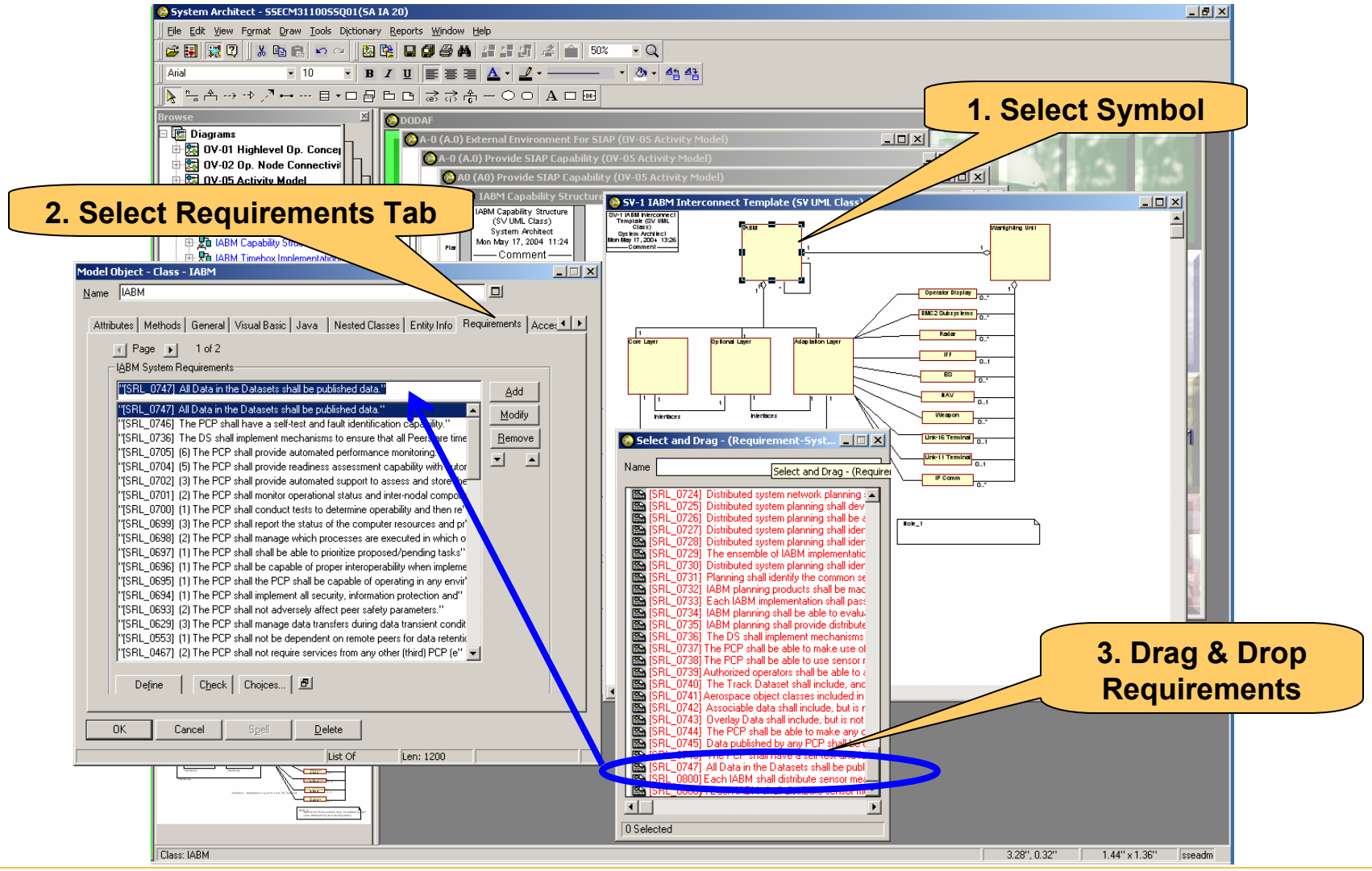
- MS Excel
  - CSV Files for Export/Import of Requirements Between DOORS & System Architect
- MS Access
  - Statistical Reports on Requirements Management
  - SQLServer Import/Export of Architecture Data
- HTML
  - Browser Viewable Reports of Architecture Elements and Associated Requirements

Popkin System Architect

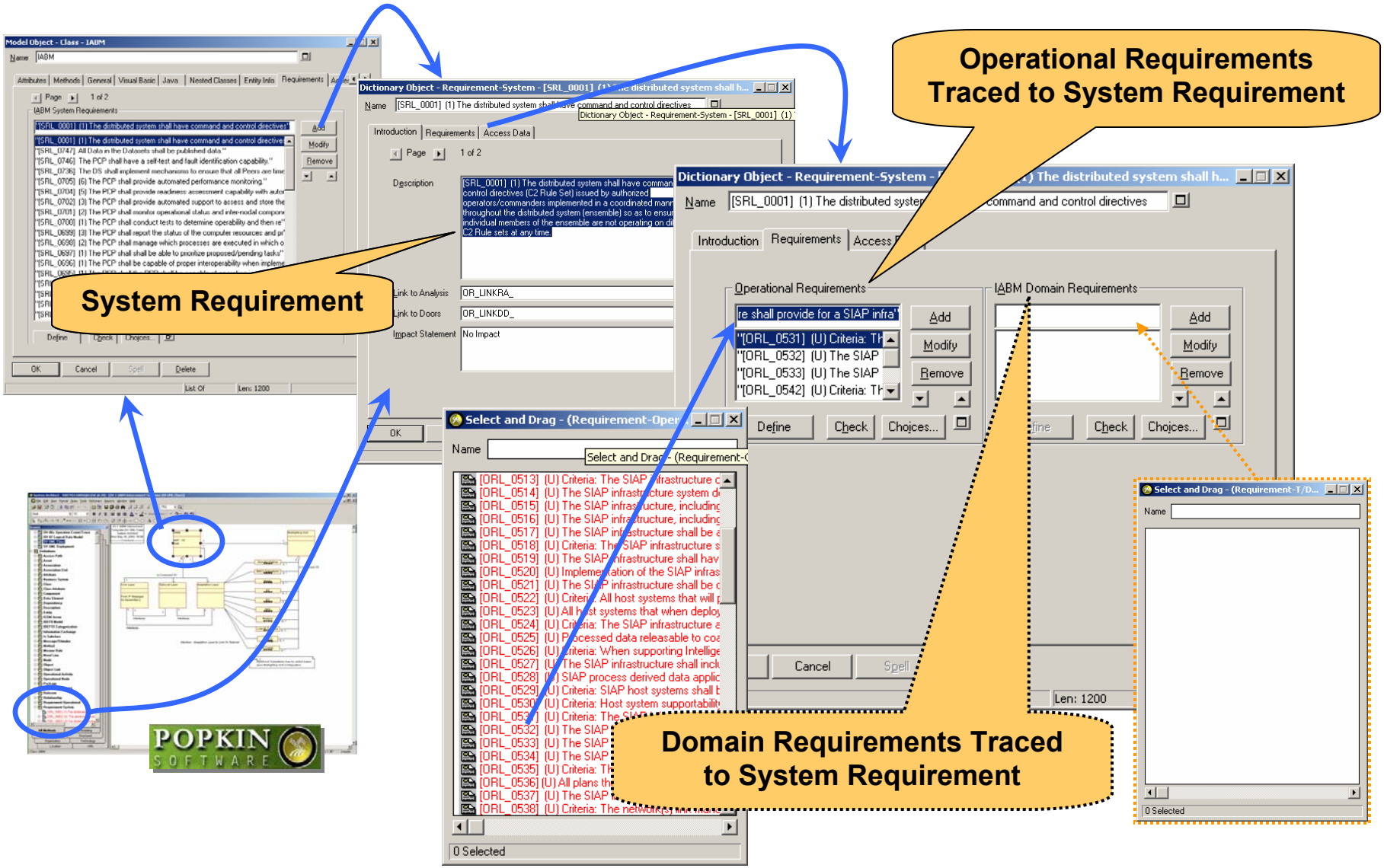
- Configured for JSSEO Development Process
  - UML for System Views to Align with UML in MDA
- Modified USRPROPS.TXT file
  - Added Requirement Definitions (Addressables) for Operational, System, and Domain Requirements
  - Extended Symbol Definitions to Accept Associations of Requirement Addressables
  - Extended System Requirement Definition to Accept Associations of Operational and Domain Requirement Addressables
- Used to Build DoDAF OVs and SVs
- Imports Requirements from DOORS Repository (via Excel Files)
- Assigns Requirements to Diagram Elements
  - Drag and Drop Requirements to Diagram Symbols



Attaching Requirements To A Symbol



Defining Requirements Linkages



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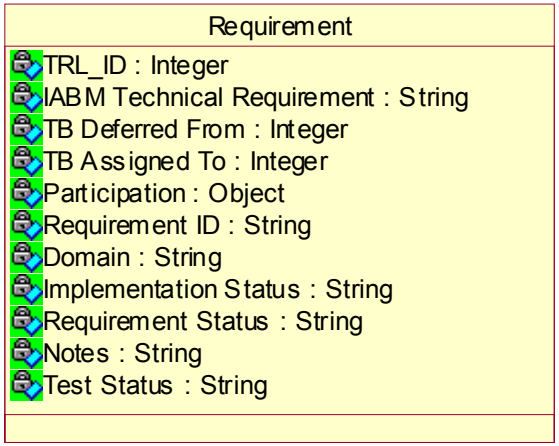
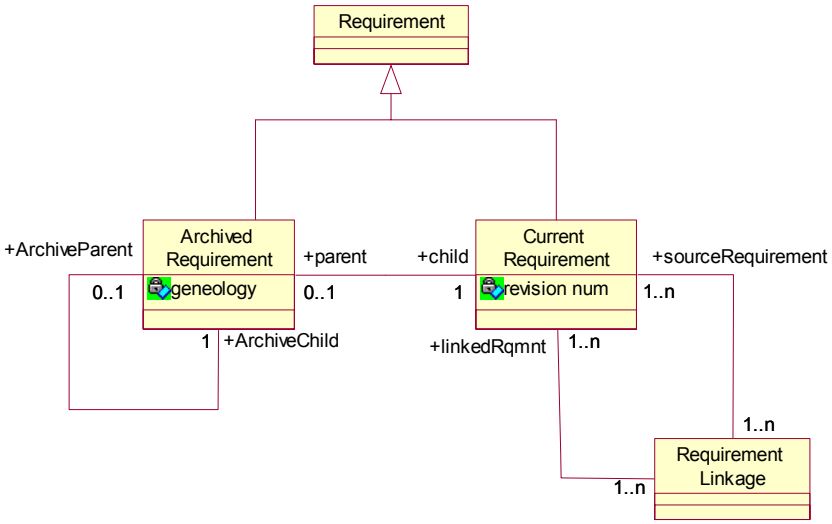
Requirements Management

- Requirements Database in DOORS
  - Independent Operational, System, and Domain Requirement Lists
  - Unique Identifier for Each Requirement
  - Requirement Attributes for Status Tracking
- Traceability to Source Documents, Between Requirements and to Architecture Elements
- Reports on “Orphan” Requirements or Architecture Elements Produced from both SA and DOORS

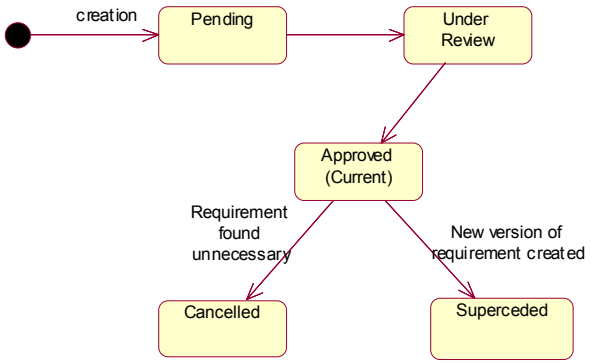


Requirement Internal Meta Structure & States



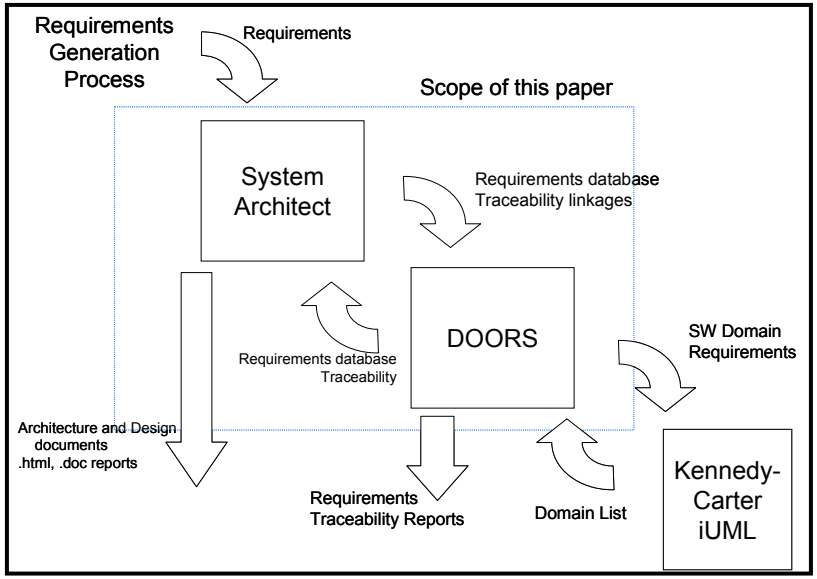
- Only Current Requirements are Linked
  - Linkages to Diagram Element, Other Requirements, or Source Document
- Superseded or Cancelled Requirements are Archived

Requirements Class State Chart



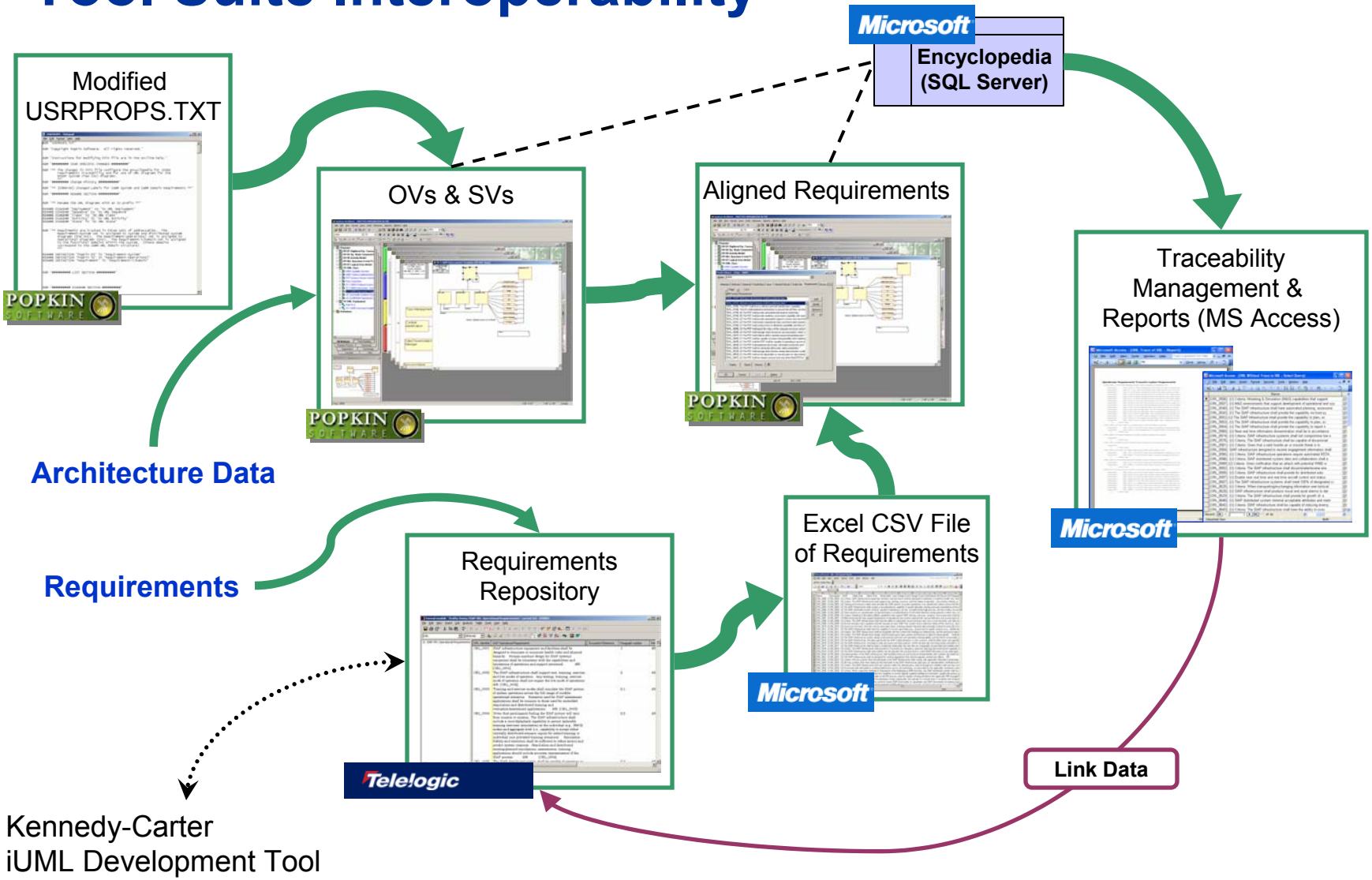
- Requirements are Approved Prior to Assigning Linkages
- Requirements, Once Created, Stay in System

Requirements Work Flow



- **Movement of Requirements Between Tools Requires Adaptation of 'One Fact One Place' Program Goal**
  - **Requirement Definition in DOORS**
    - **Exported to System Architect**
  - **Requirement Relationships Defined in System Architect**
    - **Exported for Detailed Reporting**
    - **Exported to DOORS for Traceability Management**

Tool Suite Interoperability



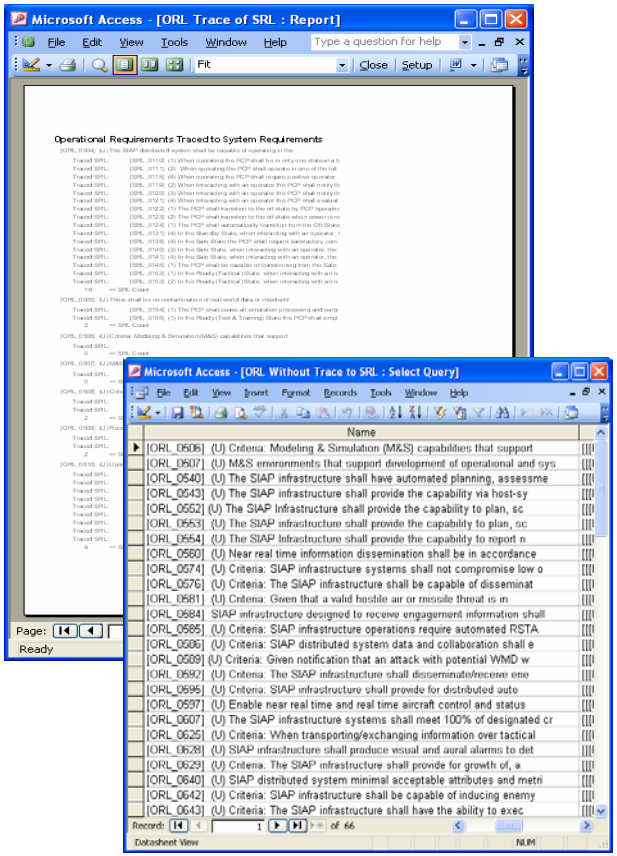
Metrics and Reports

- Measuring the Goodness of Traceability
  - Completeness of Architecture Views
  - Completeness of Requirements Set
- Traceability Statistical Reports
  - Used to Assess Architecture and Requirements Traceability
  - Requirements Traced into the Architecture
  - Architecture Elements Aligned with a Requirement
- HTML Reports from System Architect and DOORS
  - Provides Access to Architecture and Requirements Information without Requiring Expertise in Tools
  - Permits Wide Review Without need for Special Tools

Reports used to Improve Overall SIAP Development Process

Requirements Traceability Reports

- Reports Built in MS Access using Data Extracted from System Architect Encyclopedia (MS SQL Server)
  - Architecture and Requirements Traceability
  - Requirements Accounted for in the Architecture
  - Architecture Elements with Assigned Requirement



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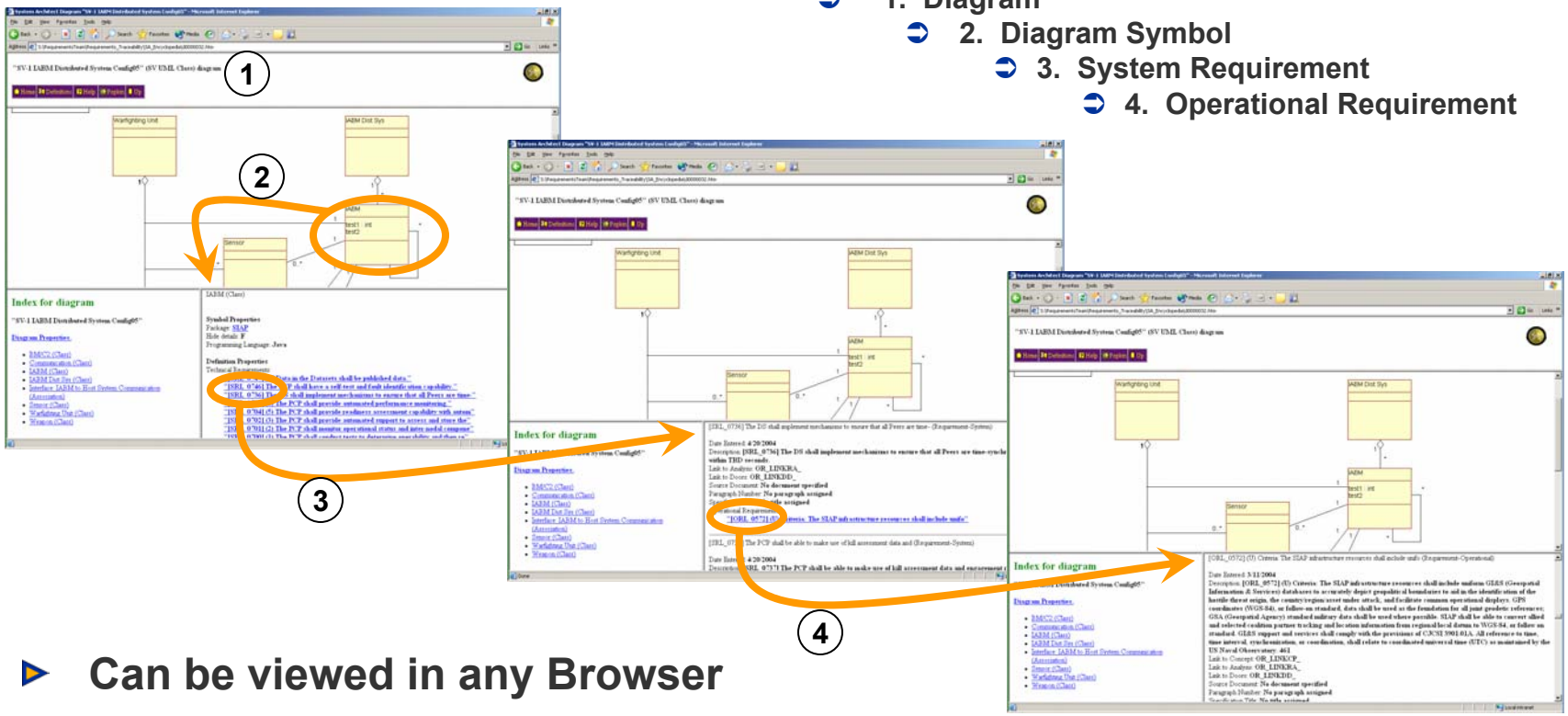
HTML Reports

- 1. Diagram
  - 2. Diagram Symbol
    - 3. System Requirement
      - 4. Operational Requirement



- Can be viewed in any Browser
- Hyper-Linked Data
  - Symbols to Symbol Definition (Includes Assigned Requirements)
  - Requirement Name to Corresponding Definition
  - Requirements to Requirements

Future Work

- Comprehensive Hyper-linking
  - VB Scripts used to create hyper-linked Integrated Architecture
  - Linkages with HTML from DOORS and iUML Tools
  - Complete Requirements Trace From Source Documents to IABM Domain Classes
- Additional Reporting & Analysis Features
- Direct Database Exchanges to Minimize need for File Export/Import to Move Data between Tools

Summary

- Presented the Approach for Linking Architecture and Requirements.
  - Architecture Views Serve to Place Requirements in Context
- Demonstrated the Current State of **JSSEO** Products, Metrics, Reports
- Metadata Structure, Configuration Data in the usrprops.txt file, is U.S. Government Owned, and Releasable (through JSSEO)
- Requirements Must Be Developed By All, Integrated With Architecture

Requirements, Design, or Behavior that is not Part of an Integrated Architecture is not Defensible